TT F-9173-

N65 11311

(ACCESSION NUMBER)

47

(PAGES)

(NASA CR OR TMX OR AD NUMBER)

/

(THRU)

(CODE)

28

(CATEGORY)

FACILITY FORM 602

OTS PRICE

XEROX $ 2.00 FS

MICROFILM $ 0.50 mf

NASA TT F-9173

NASA TT F-9173

EXPERIMENTAL ROCKETS, AN AUXILIARY TEACHING AID

Lise Blosset

Translation of "Les fusées expérimentales, moyen auxiliaire d'enseignement."
Paper presented at the 15th International Astronautical Congress, Warsaw, 7-12 September, 1964.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON NOVEMBER 1964

NASA TT F-9173

EXPERIMENTAL ROCKETS, AN AUXILIARY TEACHING AID

Lise Blosset[1]

SUMMARY

The Minister of State in charge of Scientific Research and Atomic Energy and Space Problems has established a program designed to encourage space studies, and it is in accordance with this program that the National Center of Space Studies (CNES) makes use of rockets as teaching aids.

The CNES has undertaken the study and construction of standardized rocket engines, which it puts at the disposal of young people who have acquired a background of relevant scientific and technical studies and experiments.

These engines are capable of vertically launching a rocket, having an initial weight ranging from 27-35 kg, up to an altitude of from 3,500 m - 5,000 m.

Under the control of CNES engineers and technicians the youth groups undertake the further study and perfection of their experiments and of recovery systems, as well as the actual construction of the rocket part which will house the instruments. On the local level they are most often advised by a faculty member who may be a science professor or a laboratory teacher. At the present time we have 23 such groups with more than 450 participants altogether.

The present report will describe major rocket experiments accomplished or under way, and it will show how young people are getting to know the technical

[1]Chief, Information and Documentation Branch, National Center of Space Studies, Paris.

problems involved and to realize that there are gaps in their theoretical background, which helps them to make the necessary effort to fill these gaps.

The authorization for a launching is only given after strict control of the construction of the rocket body and of the instruments, and after proof is obtained of the usefulness of the planned experiments.

The ground facilities needed for the launchings--firing range, launching material, communications networks, etc.--are obtained through official and private cooperation with CNES.

The rocket experiments are of far-reaching importance in education: they complement the classical courses and furnish the opportunity for acquiring and using the scientific and technical knowledge which is not generally taught. They determine certain research vocations in scientific or technical fields. They also teach the usefulness of team work and contribute, during a program lasting several months, to the development of such qualities as patience, seriousness and strict discipline indispensable to working in scientific fields.

Table of Contents

Foreword /1*

It is our idea that the study and launching of experimental rockets by and for young people and all related experiments are extremely important auxiliary teaching aids. The activities described in the present report seem to prove this theory.

In order to introduce space techniques into the field of education it is necessary to take various factors into consideration, such as age group, level of theoretical or practical background, aptitude for absorbing new ideas, environment (school, extracurricular groups). It is possible to lead young amateurs from practical experiments to empirical research by giving them the materials necessary for experimental launchings to be effected under strict control. Or, if the group is composed of young people who are equipped with adequate scientific background, it could be tried to orient them from the starting point of theoretical background towards the experimental verification obtained through space shots. In this way the essentially educational feedback from theory to practice and vice versa becomes apparent.

We are, therefore, facing a method of teaching which in the field of rocketry leads to endless motivations. This holds true provided of course that the abstract study leads always to practical verification, which is sometimes the source of creative invention. It is also important that practice based on abstract or purely empirical knowledge always be placed under the supervision of teachers familiar with these problems, so that, by going back from practice to theory, it is possible to trace the applications back to their theoretical foundations. If rockets are used as described here, they will contribute to the field of education in consolidating and expanding a knowledge where practice and theory work hand in hand.

*Numbers given in the margin indicate the pagination in the original foreign text.

Real tests awaken the curiosity and hold the attention of the participants by their diversity, since the rocket launchings are combined with systematic programs involving scientific experiments and various technical studies. The interest is developed and deepened by a successful or even partially successful launching of a rocket. Even a failure contributes to progress, because the theoretical or technical error must be found.

The introduction of astronautics and space research into the field of theoretical and practical education fulfills still another good purpose. By its novelty and its originality this kind of education exerts an intellectual as well as a moral influence on the young people who receive it and actively participate /2
in it. Intellectually, our young people become familiar with topics which, although they are not entirely new, come in especially attractive form, if only because they are closely related to action. The need to work collectively at a task whose scope and complexity exceed individual possibilities exerts a further beneficial influence. Numerous technical difficulties and incidents, happening to each small team, are the elements which build up character and morale.

Our scientific education in France has never had such great opportunities as those offered by the study and use of rockets and by the large field of space research. A renewal has begun which will continue and increase in importance. We can see the day when the relationship between practice and theory and between theory and practice will open attractive research possibilities to all young people, whether they are of the manual or of the conceptual type.

It is thus that individual vocations are born and the valuable and indispensable qualities are developed which are necessary to team work.

Chapter I

Since the first artificial satellites were launched in 1957 and 1958, hope has become certitude that space techniques will open to men a tremendous field of new knowledge. In situ space studies and the reality of astronautics have aroused the enthusiasm of all peoples. The spectacular results obtained by the Soviets and the Americans have provoked, especially in young people, an intense curiosity regarding space problems. One proof of this are their--often awkward--attempts to launch rockets.

In France, as in other countries, space exploration has captivated the interest of the young people who formerly dreamed of colonial conquest, aeronautics, atomic research, etc. The present generation of teachers, who are either aware of these problems or pushed by their students, make an effort during practice sessions to explain great theories with the help of concrete examples taken from top scientific and technical fields. Even on the recreational level efforts are made to offer means for experimentation in order to develop a taste for science and technology. In this respect it should be noted that the percentage of young people in the French population has considerably increased, so that the government faces a national problem in this field of youth recreation.

For several years the departments and organisms specializing in space research have been swamped with requests by young people for advice and help concerning launching of rockets. Unfortunately, many accidents happened during the development or firing of missiles. When CNES started its activities in 1962, it therefore encountered a situation rather disorganized, but relatively favorable as far as work with young people was concerned. Starting in June 1962, the Information and Documentation Branch of CNES has taken up the matter of young /3 rocket launchers. Its role was to study and to establish means for furthering scientific vocations and to plan activities which would bring adolescents in contact with problems encountered by researchers, engineers and technicians, always keeping in mind the essential need for safety.

Government authorities intervened beginning August 7, 1962. The Ministry of the Interior, after consulting with the Ministry of the Armed Forces and with CNES, published a memorandum prohibiting the launching of experimental rockets without control. This control was to be effected by the CNES, whose Information and Documentation Branch had created from the very beginning a Youth Section. CNES was also charged with the direction of the space projects and with the establishment of all useful safety measures (see Appendix I, Memorandum of the Director General of the Sûreté Nationale). The handling of products forming the composition of propellants is dangerous. French law prohibits the fabrication and firing of explosive mixtures by individuals, and any violation is severely punished. Only the Direction des Poudres (Explosive branch) and certain officially authorized laboratories are permitted to make propellants.

At the same time an initiative was taken by Mr. Gaston Palewski, State Minister in charge of Scientific Research and Atomic and Space Problems, who decided to launch a program designed to encourage space studies among young people.

We will give a summary of measures taken by the CNES in order to carry out this program and to answer the call of young people interested in space problems. It was necessary to channel their interest and to give them the means for carrying out experiments. It was also necessary to profit from the circumstances and to give adolescents the taste for reference research, for the establishment of bibliographies on new subjects, for observation and experimentation and for the interpretation of results. Briefly, their scientific minds had to be developed.

In the fall of 1963 the program was ready to enter the phase of pratical applications. The first results obtained were positive in many fields. Because of their repercussion and in spite of the fact that it is still very early, we will here take up the hopes and aspects of the policies followed by the French national space research organism with respect to young people.

Chapter II

CNES Policy with Respect to Young People

The first task of CNES was to check the few existing groups (there were /4 four of them), as well as the individual people having expressed serious interest in space problems, and the means of grouping them. It became immediately necessary to teach elementary safety rules. CNES did this by preparing useful textbooks and distributing them on a large scale.

The first recommendation of the CNES to young space amateurs was to refrain from attempts to fabricate propellants, i.e., not to build rocket engines. This intervention was especially necessary because the risks involved in the handling of explosive mixtures are out of proportion with the interest that such operations may present. Young experimenters can obtain nothing but unstable compositions, whose specific impulse is very weak compared to that of commercially fabricated explosives. In addition, young people do not have the means of making any progress in the chemistry of propellants.

The young people, who had made themselves familiar with the problems posed by space studies, had to convince themselves, little by little, that the real goal was not only the launching of a rocket. They have, step by step, undertaken the necessary intellectual effort and have understood that a rocket is interesting only if it is not a goal in itself, but a tool for making fascinating observations and experiments.

CNES then decided to define the types of propellants which the youth groups might use; calculation and fabrication of the propellants were entrusted to specialists. Young people are interested in the various aspects of space research and want to learn first about the technological problems encountered by engineers and technicians. For this purpose it is, indeed, necessary to equip them with the means for launching, to a sufficiently high altitude, a rocket capable of housing instruments and a parachute with its control device. Taking into consideration the means at the disposition of youth clubs, it cannot be expected that they will be able, from the start, to produce miniature equipment, which means that the experimental payload runs the risk of becoming relatively heavy. The average payload weight has been estimated at 5 kg. To this must be added the weight of the rocket body, also constructed by the young people themselves. The rest is the engine.

Since none of the presently available rocket engines is exactly suitable, CNES decided to have a standardized engine designed and constructed, which would then be given to these youth groups which presented a program of experiments judged sufficiently interesting. The final choice was an engine (see Appendix II, Engine Characteristics) capable of launching vertically a rocket having an initial weight ranging from 27 kg to 35 kg to an altitude of from 3,500 m to 5,000 m. This engine is built by the Technical Association for the Study of /5
Rockets under the name of ATEF-74 (fig. 1). This engine is a "shorter" version of a model widely used by the Ministry of the Armed Forces for the launching of propelled targets or of light or smoke canisters. The functional safety of the engines on which the ATEF-74 is based was already a certain guaranty. In addition, CNES has submitted the standardized engine to a series of ground and flight tests (fig. 2), under the control of the Ministry of Armed Forces, in order to make sure that this engine could safely be put at the disposition of young people, who are fully informed of the precautions to be taken during any firing sessions.

The rocket bodies, constructed by the youth groups, must be adapted to the standardized engine and must be designed to insure the stability of the space vehicle. Certain limits have been established with regard to their weight, size and position of the gravity center (fig. 3). CNES does not, however, furnish any plans of rockets or devices, because that would take away from the young people all initiative and all personal and original work. The rocket body is attached to the engine by a standardized coupling piece (fig. 4), which is given to each youth club who has submitted an interesting project to CNES. Starting with this piece, it is possible to proceed to the actual building of the rocket body. One can thus be sure that the rocket body is automatically adjusted to the engine. This method permits the final assembly on the launching site and avoids the handling of a fuel-containing engine by young people at a time when there is no control.

The size of the rocket body is large enough to house numerous devices. As an example it is worth mentioning those included by a Parisian youth club: small parachute, main parachute of 3.50 m diameter, parachute ejector device, parachute opening-timing control devices, electric 8 mm camera to film the ground, container for biological experiments (heart beat and respiratory rhythm of a rat), and a telemetering transmitter designed to transmit to the ground the altitude given by an altimetric capsule and the measurements obtained on the rat.

CNES has stressed in its advice to young people that isolated work is not effective in this field. CNES has also insisted that young people do not try to build a rocket by themselves. Building a rocket is a delicate, long and difficult task. It can only be the result of collective teamwork. The young people must work together in planning a program, then conceive and carry out a coherent system, where each part must be thoroughly checked, first separately and then again after integration into more and more complex structures. This program could, for instance, be composed of the following:

1. Measurements concerning the performance of the rocket itself. This performance could be made the object of a theoretical calculation which will later be compared to the results obtained during flight.
2. The development of recovery methods for the rocket and its payload (instruments, animals, etc.). /6
3. The use of complex instruments--telemetering instruments, for example,--for groups of young people of high educational level (students of engineering and of the Faculty of Sciences).

The building of a rocket and the establishment of a scientific experiment program require a minimum of basic knowledge. It is, therefore, desirable that the associations interested in rocketry select members who have an educational background corresponding at least to that of the "baccalaureate" of mathematics or of experimental sciences or to the technical "baccalaureate". This does not mean, however, that they must exclude young people of a lower educational level such as high school students, technical college students, workers or apprentices. They should enlist the help of a professor (physics, mathematics) or of a shop or laboratory teacher, engineer, technician, commissioned or noncommissioned officer of technical branches or other qualified person capable of teaching and guiding the young launchers. At any rate, whatever the club or association, it must be placed under the direct responsibility of an adult. It was this grouping of the young experimenters which entailed difficulties in the beginning, most of which have been overcome at the present time.

CNES tries, therefore, to develop in scientific activities of young people an interest to be shared by member of the educational profession (teachers of high schools and technical schools), engineers, military personnel of the technical branches, leaders of youth organizations, and parents of students (whenever they have a technical background). It is the goal of CNES to offer these people the help and advice they may need.

Requests addressed to teachers asking for assistance and advice have generally been well received. The good will of one teacher is not always sufficient, however, to resolve the numerous problems which occur. Experience has shown that the schools themselves are the most favorable places for the constitution and development of scientific clubs.

In addition, military personnel and science or engineering students not yet finished with their studies are quite willing to share their theoretical and practical knowledge with young people who desire to work on space experiments. The problems encountered in enlisting adults absolutely indispensable to such activities are, therefore, being resolved at the present time.

CNES has undertaken to regroup, according to region or city, the young people who had addressed themselves to CNES. This entailed an important work of putting the young people in contact with each other in order to create useful groups. CNES then approached the directors of youth associations, the State /7
Secretariat for Youth and Sports, teachers associations, governmental and local authorities, as well as superintendents and professors of educational establishments in order to obtain the necessary aid for the youth groups.

A first statistic, containing 300 cases examined in 1963, shows that construction of experimental rockets interests not only high school students aged 14 to 19, but also adults with a high educational background (college students, technicians and engineers), for whom these activities offer an opportunity to use their acquired knowledge or to complete their education.

The high school students between 14 and 16 years of age approach the experiments in a purely qualitative way, they proceed empirically and have no precise idea of the theoretical and technological problems involved.

What characterizes the young people between 16 and 19 years of age, in spite of the considerable difference of educational level between a high school student and a candidate for institutes of higher learning, is the desire to build a vehicle functioning accurately and capable of including a recoverable payload of measuring instruments. More than 50 percent of these young people take or have taken courses at technical schools and plan to construct the materials themselves according to their own calculations. The questions they address to CNES concern methods for calculations or certain techniques for carrying out their plans.

As an example we want to mention that 850 requests by young people interested in rocketry were received at CNES between September 1, 1962 and September 1, 1963, and 610 between September 1, 1963 and April 1, 1964. Of the latter, 460 came from individuals and 150 from members of regularly constituted groups.

Students as well as teachers are well aware of the complexity of the problems posed by the launching of a rocket meant to carry instruments for physical or biological experiments. The final success of the experiment depends on the good functioning of all elements involved. With the exception of the factory-built engine, all parts of the system are constructed by the club members. The least calculation error, an incorrect estimate of the apogee, the inaccurate adjustment of timing-control devices or poor transmission of radio signals can have irreparable consequences with regard to the operation of the recovery device, and lead to the destruction of the vehicle and the instruments on board. This risk has been accepted by the young people. From a purely pedagogic standpoint such large enterprise is interesting enough to attract teachers. Their contribution was necessary, and it finally turned out that their work was facilitated by the creation of an atmosphere of mutual confidence and collaboration.

It is desirable that school principals--inspite of their numerous responsibilities--become more aware that the spontaneous scientific activities of young people are of importance not only from a pedagogic standpoint, but also because they contribute to the professional education of future staff members. /8

Whenever there is a group of young people eager to build a rocket, teachers face the urgent task of instructing them in the necessary theoretical and practical steps which will enable them to carry out the preliminary calculations correctly and to interpret the results. These include trajectory calculations, taking into account resistance of air, weight of the vehicle and engine characteristics; measurement of altitude by means of a barograph or by optical triangulation; measuring of velocity by Doppler effect; radio tracking, etc.

A great number of young people who contacted CNES deplore the absence or the insufficiency in their school textbooks of chapters or exercises dealing with these new centers of interest. It seems that the development of programs, in spite of reforms, has not kept pace with a youth becoming more exacting. Prominent members of teachers' associations are presently studying possible solutions of this problem. CNES is convinced that all teachers not indifferent to the questions asked by students will be glad to contribute to this study.

CNES and the French Society of Astronautics have just published a teacher's handbook containing chapters by the best specialists in the field and answering the need for a renewal of the sources of education. Its title is "Astronautics and Space Research". This book is designed to encourage authorities and teachers to teach mathematics and physics courses in high schools and junior colleges by presenting new examples taken from the space field and new points of view to explain classical principles.

Together with the inventory of requests, the first contacts and the development of engines, CNES has undertaken the distribution of general information on the goals, means and results already obtained in the space field. An effort was made simultaneously to reach the young people and their teachers by detailed articles published in the daily newspapers and in specialized periodicals. An information campaign was carried out through radio and television.

We might mention in this respect a series of astronautics programs for the /9
1963 school television, and various interviews of young people for television and designed for professional and vocational orientation. Panel discussions on radio have aroused great interest. The participants were members of CNES, teachers, high school and university students and young technicians of CNES.

CNES has especially oriented its efforts to the interest of young people by giving its exhibits an educational character. A great number of photographs concerning French space activities and of satellite and rocket models were given on loan to youth associations to be displayed at local meetings. Well-documented articles were published in "The National Education", a magazine distributed throughout educational establishments, as well as in bulletins of teachers' associations, such as the one of the Physical Society. CNES has also largely contributed to the formation of astronautics sections in youth and cultural centers. Finally, a spectacular initiative was taken by CNES on the occasion of its presentation of a space research paper at a conference of the Northern Regions (Lille): among the items to be won at a raffle were two trips to the French launching range in Algeria. The two winners will assist at a series of scientific launchings of space probes.

CNES is well aware of the fact that space studies involve considerable expenses for young people and therefore tries to contribute to the financing of the group activities. It includes in its own budget the rocket engines stages and the help of a technician. In addition, CNES has contacted the official authorities, such as the Ministry of National Education, the State Secretariat for Youth and Sports (CNES has its main office at the Youth Science Committee, which is part of the High Committee of Youth), and the State Ministry in charge of Space Research. CNES has suggested that these authorities also make contributions.

Special mention should be made of the aid offered by the Ministry of the Armed Forces in this field. They put the launching fields at the disposal of the youth groups, they furnish means of transportation and they have furnished, free of charge, equipment in good condition, but obsolete.

In addition every effort is being made to obtain the cooperation of private firms (such as gifts of equipment by electronics companies, for example).

Finally, the young people are encouraged to collaborate as much as possible with clubs or associations whose activities can help with the development of scientific experiment programs, such as radio amateurs, electronics amateurs, amateur camera men, amateur astronomers or meteorologists, etc.

The general plans proposed by CNES at the beginning were being worked out /10
little by little in more detail. The isolated young people made contact, clubs were formed, buildings were found and adapted, adult supervisors became familiar with the problems, experimental projects were started and the requests for launching authorizations started coming in. It became necessary to face numerous small but essential problems, such as taking out of insurance policies. The organizing of the groups themselves had to be watched closely, guidance and instruction was indispensable for the preparation of experiments, building of the rocket body, and the control over the whole assembly by CNES. Necessary steps were taken for the recovery of any equipment that could be used again. Everything had to be

planned in such a way as to insure complete safety and to guaranty a certain measure of success to the young people and the adults in charge.

They furnish newly forming groups with directions and guidance concerning the various ways in which a club can be constituted and the contacts which can be established between the clubs and local associations or national organizations of specifically scientific character.

They give all groups practical advice as to building and launching of experimental rockets, in particular of rockets using the standardized engine stage ATEF-74.

They help obtain all the necessary information so that CNES can guide and control the group activities. This is done by two questionnaires. One concerns the organization of each group, the educational level and staffing of its members, its financial means, its techniques and equipment. The other one concerns the planned program of experiments: recovery device for payload and engine, measuring principle and related equipment (accelerometer, anemometer, altimeter, thermocouples,...); specific experiments, e.g., biological experiments (heartbeat of an animal, respiratory rhythm, electroencephalogram,...); transmission of signals (principle of the transmitter, carrier frequencies, mode of modulation); ground reception of the telemetering and mode of data transcription; possibly camera work, remote control and radio tracking; and finally the calendar for detailed planning of study and construction of the rocket and its experimental equipment. All schematics, drawings and construction plans must be furnished for the rocket structure as well as for the mechanical and electrical devices and the electronic components.

A detailed report of the plans and projects, verified by a qualified technical consultant, is therefore indispensable for obtaining the engine stage and the means for launching (sites). We also recommend that the various projects /11 be grouped, in as much as possible, on a regional level. This permits the selection of one launching site for several clubs. CNES examines the projects and helps the interesting ones.

Clubs whose projects have been approved are required, prior to launching, to establish a checklist of detailed and chronometrical description of all operations to be performed on site up to launching of the rocket. The checklist must mention how the work is distributed among the group members. The result of each operation must be reported on the checklist during and after the experiment.

Chapter III

Activities of the Clubs and Results of First Rocket Launchings

There are now in France 23 regularly constituted clubs with approximately 450 members, 370 of which are students of secondary schools (high schools and technical schools) and 80 are students of engineering schools. Most of the clubs belong to either one of two organizations. One is the movement "Youth-Science" (5 groups), the other one is the "National Association of Scientific Club" (16 clubs). In addition, the "French Cosmos Club" is interested in theoretical studies and in scientific and technical documentation. The club "Aviation-Youth-Space" has been created very recently and is only in the organizational stage. Seven clubs are in the Parisian region, 16 in the provinces.

The following is brief indication of the average age and educational level of group members:

18 clubs are "high school" clubs. The students are in their senior year and the average age is 17.

5 clubs correspond to a higher educational level. The average age is 20-21.

The staff of these groups is composed as follows:

Permanent staff members:

55 persons (40 professors or laboratory teachers, 10 engineers and technicians, 5 educators from youth organizations and the Armed Forces).

Occasional Consultants:

30 adults (15 college or university professors and medical researchers, 15 engineers and technicians).

It must be expected that the time needed for the preparations of the experiments on board and of building a rocket varies between 5 months for the groups having prior experience to 18 months for the groups preparing their first launching. This takes into consideration that the club members are all otherwise busy and pursue this activity only during their spare time. /12

The table below gives an idea of the type of experiments done by the clubs of young people with experimental rockets launched in 1963 and 1964.

The equipment and necessary means for carrying out this campaign are quite important and complex. They are being furnished by:

the Ministry of the Armed Forces: vehicles and personnel, camping equipment (group tents), electric energy, firing range;

CNES: launching stand, engines and equipment, pyrotechnic tracers, three transmitter-receivers 27.14 MHz for linking ground observation posts, field telephone (stand to firing post link), equipment for setting up the stand;

by the clubs: all the other necessary ground equipment, in addition the equipment built by them and indispensable to the functioning of the rocket body itself, particularly the firing cable with its electric supply (batteries), equipment for mounting pyrotechnic tracers, hand tools, fence for the safety zone and, where necessary, equipment for optical tracking, triangulation and radio tracking.

CNES coordinates the availability and use of all these facilities and equipment.

The following launchings were accomplished starting in the fall of 1963. In November, 1963, a rocket named ALGOL (diameter 0.16 m, length 1.75 m, total weight 30 kg: 10.5 kg for the payload and the rocket body) built by members of the Association of Astronautics Amateurs (A.A.A.), was launched at Sissonne,

Experiments and planned measurements	Data furnished by CNES	Work of the young people
1) Aerodynamic stability	Maximum forward position of the aerodynamical focus	Calculation of the optimal position of the center of gravity. Weight distribution around it
	Maximum forward position of the optimal gravity center of the rocket	
2) Method of recovery	Thrust characteristics of the engine needed for the calculation of the velocity vs time curve	Determination of the optimal ejection instance of the parachute
		Electronic timing devices controlling: opening of the 2 nose cone halves by electromagnets or exploding bolts, ejection of the nose cone tip in a forward direction and powder charge separation of rocket body from engine stage
3) Acceleration measurement		1) Accelerograph, moving mass accelerometer with pen and rotating drum

Experiments and planned measurements	Work of the young people
	2) Accelerometer changing an electric quantity in order to modulate a telemetering transmitter
	Altimetric capsule: direct data reading on a drum or modulation of a telemetering transmitter
5) Biological experiments:	
a) study of an animal heart beat (rat or mouse)	Telemetry transmitter modulation (amplitude or frequency)
b) Encephalogram of animal	Telemetry transmitter modulation
c) Skin temperature	Sensitive thermocouples and telemetry transmitter modulation
6) Tracking	/13
a) Optical tracking	Tracking by theodolite and triangulation
b) Radio tracking	Radio beacon, 27, 14 MHz or 144 MHz, on board of the rocket. Ground receivers equipped with directional antennas

Aisne. The program of experiments comprised observation concerning reaction of a rat during the flight (telemetry of the heart beat), determination by telemetry of the altitude of the rocket, a film taken in flight with an on-board camera for studying the behavior of the engine, recovery of the rocket (opening of the parachute controlled by timing devices).

The results of this experiment were the following: the rocket kept its stability in spite of the premature opening of the plastic nose cone and pursued its trajectory up to an altitude of approximately 2,500 m. The rat's heartbeat was observed for short time and a correct cardiogram obtained. The camera and /14 recovery system functioned, but the parachute lines were broken during the opening of the nose cone, the speed at this moment being of the order of 300 m/s.

We think it is of interest to give some details on the two launchings accomplished at Courtine, Creuse, in December, 1963. The first rocket (diameter 0.16 m, length 1.80 m, total weight 27.5 kg, 8 kg for payload and rocket body) was built by the Group for Rocket Propulsion Studies. The experimental program comprised the following: rocket-to-ground telemetry transmission of observations of the two rats during flight (cardiogram and encephalogram), of the altitude attained, of the acceleration and of the temperature differences of the gas film alongside the cone and the cone tip. The program also included studying the engine behavior by camera and recovery of the rocket. The camera and the recovery device were operated by remote control.

The recovery ground zone could not be determined with accuracy. According to a local police investigation, the rocket nose cone came down normally, attached to its parachute after having separated from the engine stage. At about 8 km north-west of the launching place, a dead Wistar rat was found and we must suspect that the nose cone and the parachute were found and taken by a peasant.

Following this experiment, it was decided to equip the rockets with optical tracers so that they can be tracked down to the end.

The second launching of December, 1963 was prepared by the International Space Club (C.S.I.). The studies planned for the rocket named EUROPE ALPHA (same characteristics as rocket ALGOL) were the following: observations of the heartbeat of a mouse during flight and transmitted to ground by telemetry, determination of the rocket altitude, acceleration telemetry, measurement of the maximum dynamic pressure, study of the strength of electronic tubes under acceleration effects, finding of the rocket after its landing by transmitted pulses, recovery of the rocket (inertial controlled parachute equipped with a time-lock during the powered flight.)

In this case the ejection device of the parachute worked normally and was found approximately 2,000 m from the launching stand. The rocket wreckage was recovered at 500 m from the point of parachute landing. The study of the remaining pieces led to the conclusion that the parachute tie cable was too weak and broke.

The preceding examples show that the first launchings did not give all the expected results, but these half failures of 1963 were followed by 2 spectacular successes obtained in the spring of 1964 at the Camp of Sissonne and the Camp of Larzac (Aveyron).

The second rocket of the A.A.A., ALGOL-2F, served the following experimental program: determination of the rocket altitude, study of the engine be- /15 havior by camera, determination of the acceleration, optical tracking during the ascending part of the trajectory, transmission to ground by means of coded audible signals, on-board measurements with tape recording of the signals, recovery of the rocket. An electronic timing system controlled separation of the rocket body from the engine stage at the apogee, opening of the parachute and working of the camera.

The rocket, weighing 33 kg, reached an altitude of 3,600 m. The opening of the parachute, 22 sec after departure, caused the camera to start working. The acceleration signals were received on the ground, as well as part of the altitude signals. The transmission stopped when the parachute opened because the wire broke between the calibrated altimeter resistor and the modulator stage. The camera motor worked, but the film did not turn normally because the spool axis had been affected during the opening shock. With the help of tracers, lighted 7 sec before departure of the rocket, the engine could be tracked up to its apogee. A triangulation made from radio-equipped observation posts led to the rocket recovery in less than 45 minutes. The rat, wearing a space suit, withstood the ballistic flight very well and was found safe and sound in its capsule 4 km from the launching point and in the planned direction.

The rocket "ESPERANCE" launched in May, 1964 had been built by the A.A.A./O.L.M. (Local Organization of Montpellier, Herault). Its essential goal was the study of a recovery system by electromagnetic control. The program comprised in addition: accelerogram recording, transmission to ground and tape recording of modulated signals referring to altitude variations, recovery of the rocket by electronic timing which, by means of electromagnets, controlled the opening of the 2 nose cone halves and the ejection of the parachute.

Launched at an angle of 75°, the rocket (diameter 0.16 m, length 1.85 m, total weight 35 kg, 20.9 for engine and tracers and 14.11 kg for payload and rocket body) could be tracked up to more than 2,000 m by means of the tracers. The apogee altitude, as found from radio signals received at the ground, was approximately 3,500 m. The ejection control of the parachute worked perfectly and the rocket was found 4,000 m from the launching place in the launching axis. In spite of a rapid fall attributed to a tear in the parachute, the engine and the rocket body were found in good shape. Only the equipment on board had suffered damage. The accelerograph gave the following results: acceleration at departure: + 4.5 g, deceleration at the end of powered flight: - 2 g.

Two series of rockets of smaller dimensions equipped with smaller propellant loads were launched, after checking with CNES, by sections of the Youth-Science Movement, whose members are adolescents of a younger age than those using the engine standardized by CNES. These launchings were partially successful. /16

The progress made by the young people with their experiments from fall 1963 to spring 1964 is, indeed, very encouraging. One group expecially, the A.A.A., has launched a rocket during each of its 2 campaigns. At the present time, numerous projects have been submitted to CNES. During the fall of 1964, 6 launchings have been planned and will be accomplished in one week from the same firing range. Five rockets have been constructed by Parisian groups and one by a provincial group. Another group of young people has taken over the task of assuring the ground communications and the functioning of the telemetry-receiving equipment. In addition, the members of 3 provincial associations, who have already planned launchings for spring, 1965, will be present in order to gain a preliminary experience. They will participate in triangulation operations, testing of ground radio equipment and recovery of the engines.

The following experiments have been planned for these launchings:

1) acceleration and altitude measurements, either by recording of minimums and maximums, or by telemetry;

2) tests of several parachute ejection systems (as a follow-up on improvements made by 2 groups on their devices used in 1963);

3) tests of telemetry transmitters and receivers in bands of 144 and 27 MHz, in order to determine which transmitter to adopt in 1965;

4) development of a mixed tracking network: optical (theodolite) and radioelectric (radio beacons and receivers with directional antennas);

5) biological experiments on rats of heartbeat and skin temperature, with transmission to ground of the measurements done on board.

Finally, there is the report that some groups with failures now work on theoretical problems in order to improve their future results. Others are patiently preparing their first launching and apply themselves to advanced studies.

The program planned for 1965 distinguishes between

a) the group who will restrict themselves to technological experiments (rocket stability, recovery, acceleration or altitude measurements); they will compare their experience to that of older clubs;

b) the groups who have already accomplished one or more launchings and who will make an effort to develop radioelectric links: increase in range and instrument sensitivity, increase in the number of channels of the /17 telemetry instruments and increase in the number of parameters measured; recovery systems: use of subsequent parachutes with increasing surface to diminish scatter during descent; and tracking systems, especially ground facilities.

Chapter IV

Repercussions and Prospects

It seems that the necessary background for learning how to develop a rocket consists of the following topics: aerodynamics and flight mechanics (elementary parts), radio electronics, electromechanics and elementary theory of servomechanism, technology (machining methods), strength of materials, biology (elementary, if necessary).

Pointers necessary for the scientific and technical education and relative to rocketry are found by analyzing the failures and successes of the experiments. A few examples of these follow.

Two failures have contributed to acquiring a better appreciation of the forces liberated by the explosives. The use of too strong a charge for the separation of the nose cone from the engine stage had led to breakage of a telemetry circuit and to malfunction of the camera. Similarly, too strong a charge of the exploding bolt had led to breakage of the piece coupling the nose cone to the engine stage. Tests on the exploding charges are now planned more rationally: a preliminary calculation is followed by tests, step by step, starting with a low charge.

A rocket was damaged because the parachute broke. An inspection of the mishap has shown that the forces involved in the aerodynamic flow and in the shock of the parachute had been underestimated for parachute material which was too thin. The young people are in this way led to making preliminary tests of static nature or in flight, and these will become more numerous and more accurate.

Malfunctions in radio transmission have led the interested people to control, ahead of time, the quality of the components making up the transmission and receiving equipment, and to make ground transmission tests. Also the topography of the firing ranges must be seriously studied, in order that osbtacles be found that could hamper the propagation of waves. Finally, optical tracking should be included to replace failing radio tracking, since this would lead to loss of the rocket. Recognition of reliability factors now demand the addition of a second system as a safety factor.

Accurate calculations became necessary, especially by the groups which included students in sciences or engineering. A student from these groups had used a safety device on a rocket, made up of a pin to be broken by a force of 150 N, but capable of sustaining acceleration and deceleration forces. The margin of safety was very much reduced, and calculations have shown that a thousandth of a millimeter precision in machining was necessary. In addition, the reduction of /18
the test data, and the finding of the rocket trajectory as a function of weight, angle of fire, thrust, ground and altitude winds, yield the causes of success or of failure and lead to the discovery of the effects of the disturbing elements.

The young people can, therefore, become acquainted with the technical problems and whatever gaps exist in their theoretical background. They can also become aware of system and planning errors, and this leads them in turn to make the necessary effort in order to fill these gaps. This is emphatically shown by the various examples of progress accomplished in the radio communication field by young people who so far had only a theoretical background.

In addition, teamwork widens their awareness of systems and planning, and their spirit of coordination, although both must exist from the outset. Teamwork also develops in the young their patience, seriousness, strict discipline, all of which are necessary in the scientific field. It also develops attributes of a psychological nature needed for getting along among themselves.

The fact that the organization and management of these youth clubs do evolve seems to prove that the hopes which were expressed at the outset were well founded. Having started out as clubs made up of high school students, these groups now enlist their members from college students in science and engineering and from young technicians already working professionally. Since these additional elements have a much higher degree of maturity, marked improvement in the internal organization of the clubs resulted, as they began to resemble research centers. At the same time the planned experiments grew in complexity. The year 1964 was devoted to solving purely technological problems such as aerodynamic stability, recovery, measurement of basic flight parameter. CNES proposes to develop in 1965 an engine stage which will permit increase in payload and ceiling height of experimental rockets. This was requested by many groups anxious to make physical measurements on the intermediate layers of the atmosphere or to study the behavior of animals launched to much higher altitudes.

Chapter V

Conclusion /19

The efforts of CNES to help young people carry out valuable experiments in complete safety was an answer to a definite need. The policy which was selected has been applied without excess.

By presenting the rocket as a means for gathering information, CNES hopes to awaken the vocations of researcher and technician. The performance of the rocket itself is, therefore, of lesser importance than the accuracy of the measurements. The care and precision brought to the conception and development of a system are especially appreciated and encouraged. The most serious members of the teams will later form the brain trust of space exploration. Reliable, enthusiastic, used to teamwork, they will become the staff of laboratories, research centers and industries working on these pilot projects.

It can be said that the results of 2 years work are promising; the experimental rocket can justly be called an "auxiliary teaching aid".

On one hand, teachers are an essential element needed for making the clubs effective. On the other hand, the space experiments of young people actually help to renew the pedagogics of science. They facilitate education, since the concrete example is useful for better understanding of theoretical ideas. They even lead to the acquisition of new knowledge as a consequence of the documentary research they imply. It must be stressed that the enthusiasm of young people for rocketry does not keep them from achieving a good scholastic record. Those who spend their spare time in search of scientific knowledge and who work seriously in the clubs are also the best students of mathematics and physics.

Although space occupies at the present time an important place in the interest of young people, it is still too early to speak of a true orientation towards scientific careers and techniques. The effectiveness of the "youth" policy of CNES is still limited. Nevertheless, we can state that an excellent job of education and information has been started, and that the fruit of this work will become apparent when the young people become adults and take their place in the working world.

CNES is well aware that there are numerous rocket amateurs in many countries. The French authorities responsible for these activites, which in our country are tied to education and cultural recreation, would be interested to learn of the results and hopes of other countries in this field.

This brings us to formulate a wish. In view of the expenses involved in preparing scientific rocket launchings, is it too ambitious to think that young people of other countries, especially in Europe, could be meeting in international vacation camps or seminars in order to pool their work and organize common launch- /20
ing campaigns? This would require a coordinated preliminary preparation of their space experience. We would be willing to participate in such a project.

I wish to express my sincere thanks to Miss Jacqueline Defond, in charge of public relations and press at CNES, for her valuable contribution to this report, and to Mr. Jacques Delaunay, in charge of the youth program at CNES, who has gathered the information presented in this report.

Figures 5-8. Drawings of experimental rockets and ground equipment submitted by youth groups

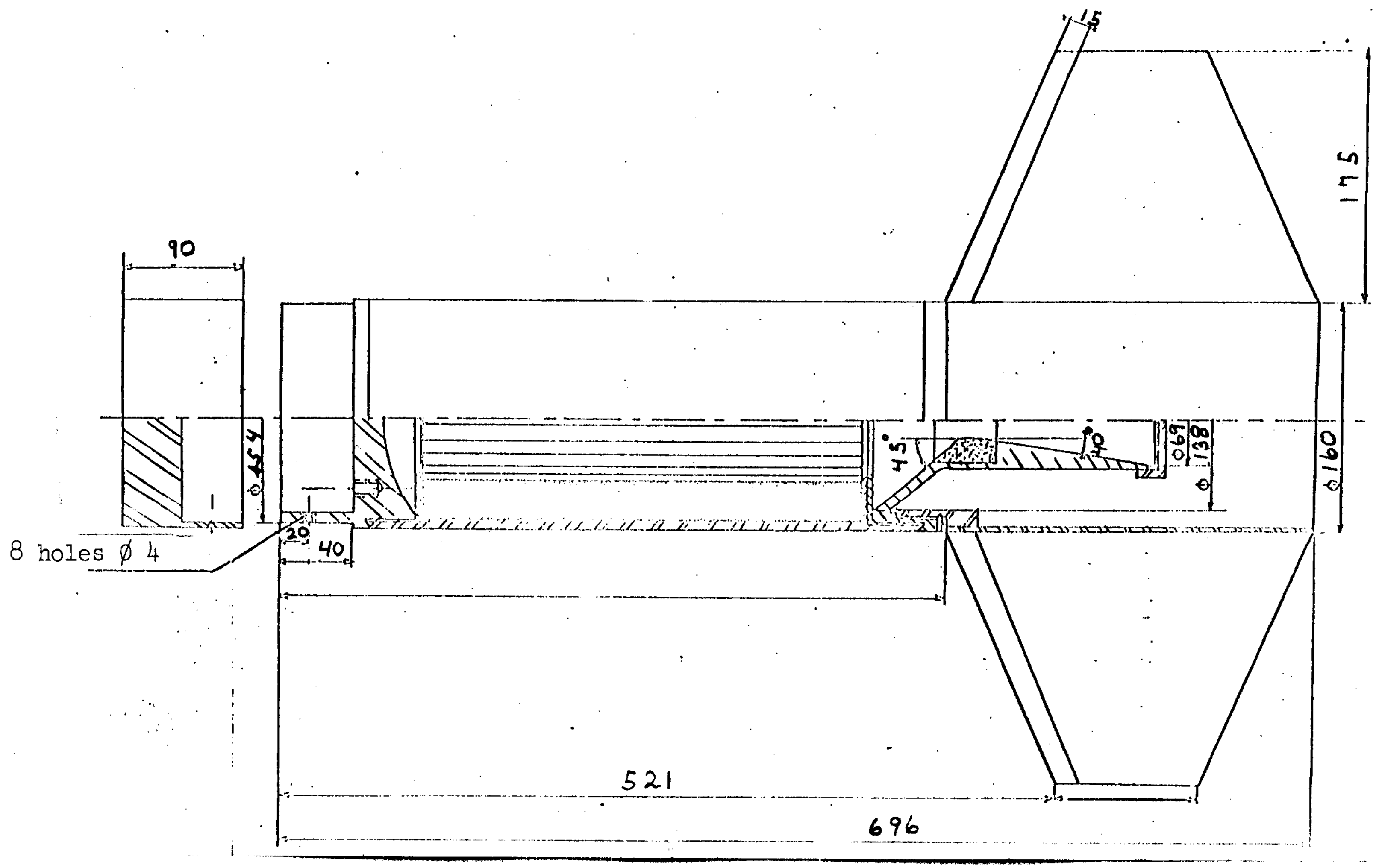


Figure 1. CNES standardized engine stage (ATEF-74)

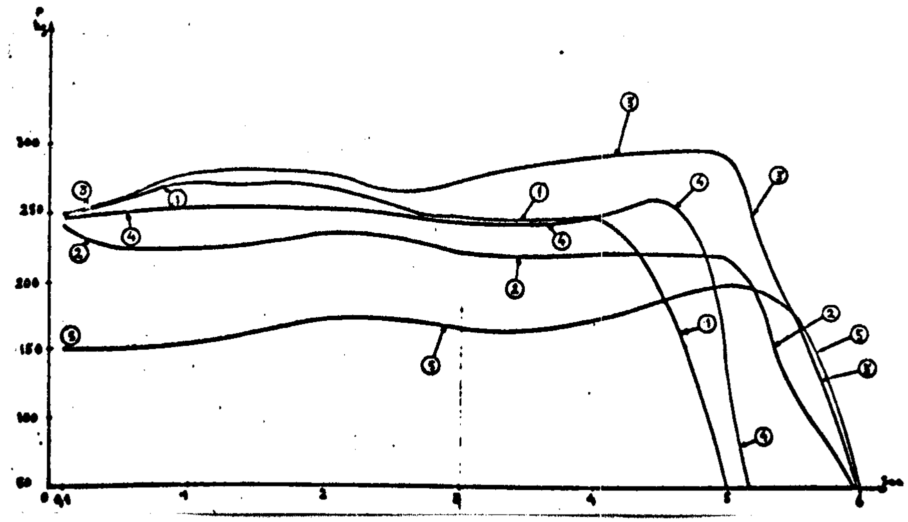
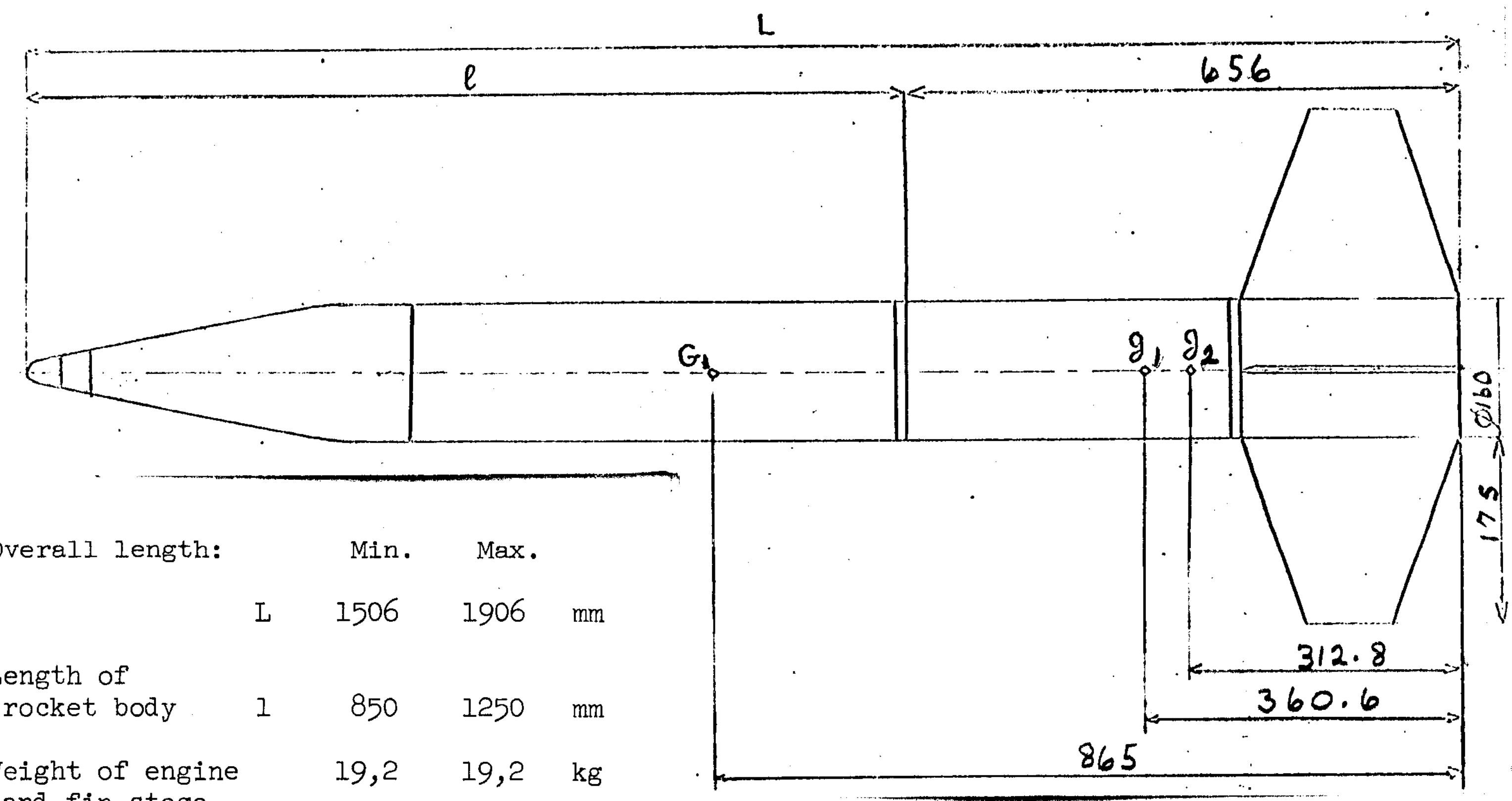


Figure 2. Bench tests of 5 ATEF-74 standardized engine stages; thrust as function of time



		Min.	Max.	
Overall length:	L	1506	1906	mm
Length of rocket body	l	850	1250	mm
Weight of engine and fin stage		19,2	19,2	kg
Weight of rocket body including --machined coupling parts, --structure, --payload		8,0	15,0	kg
Overall weight of vehicle		27,2	34,2	kg

Weight of premachined coupling part: 2,9 kg)

Center of gravity of engine and fin stage

--with fuel: point g_1

--without fuel: point g_2

Maximum forward position of center of gravity of completely equipped vehicle: point G_1

Figure 3. Standards for optimum rocket

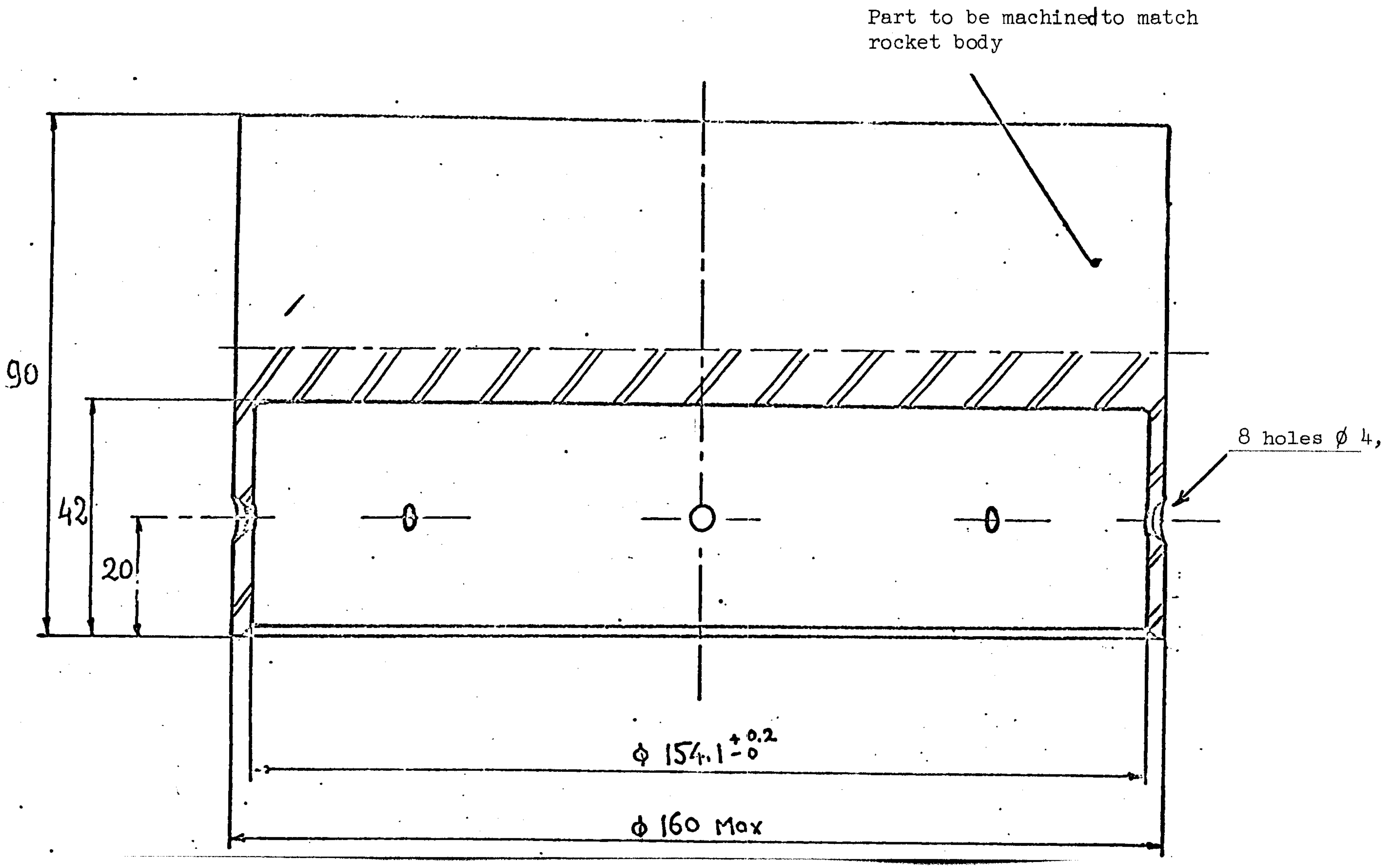


Figure 4. Coupling piece for ATEF-74 rocket engine

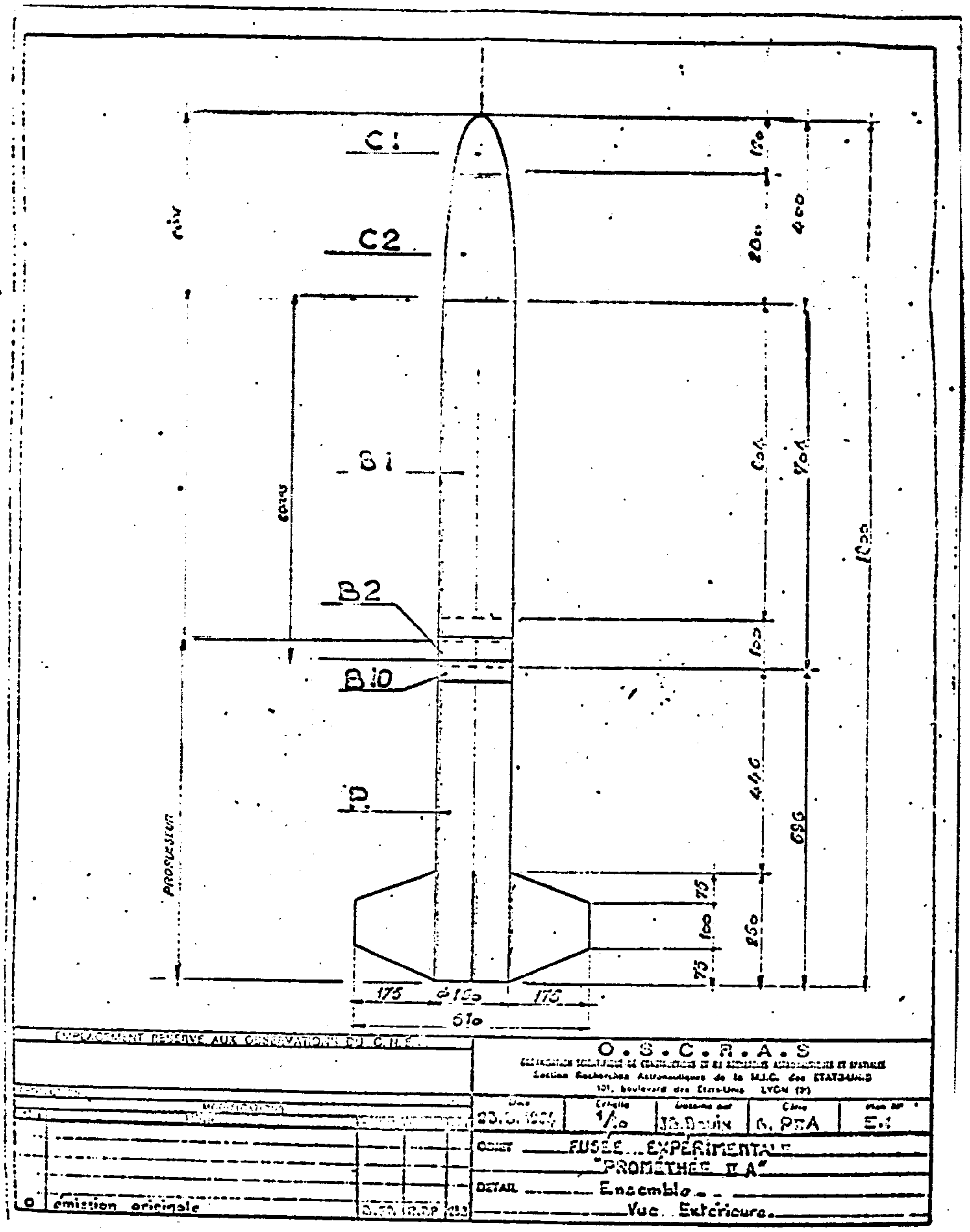


Figure 5. Project of experimental rocket

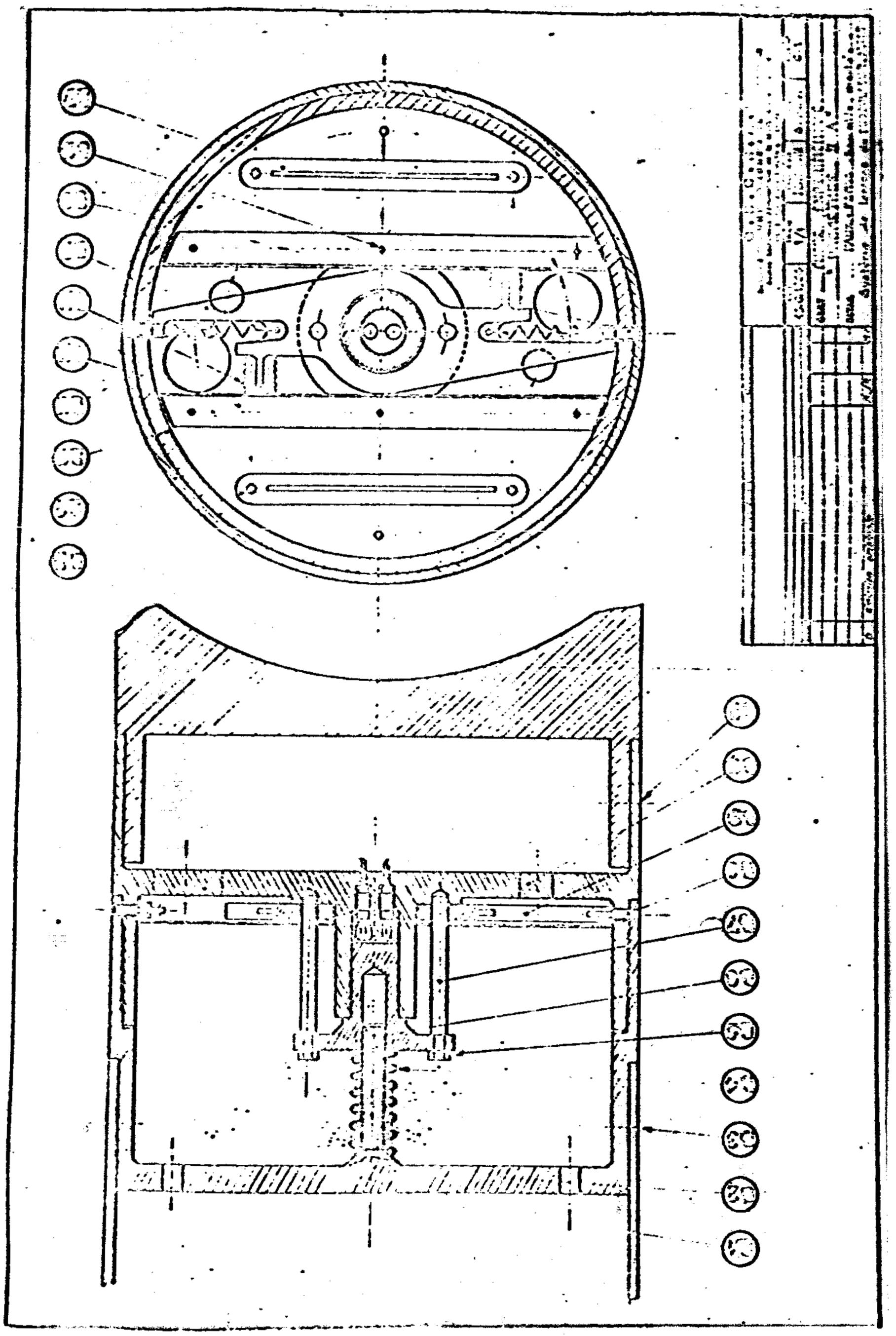


Figure 6. Device for separating nose cone from engine stage

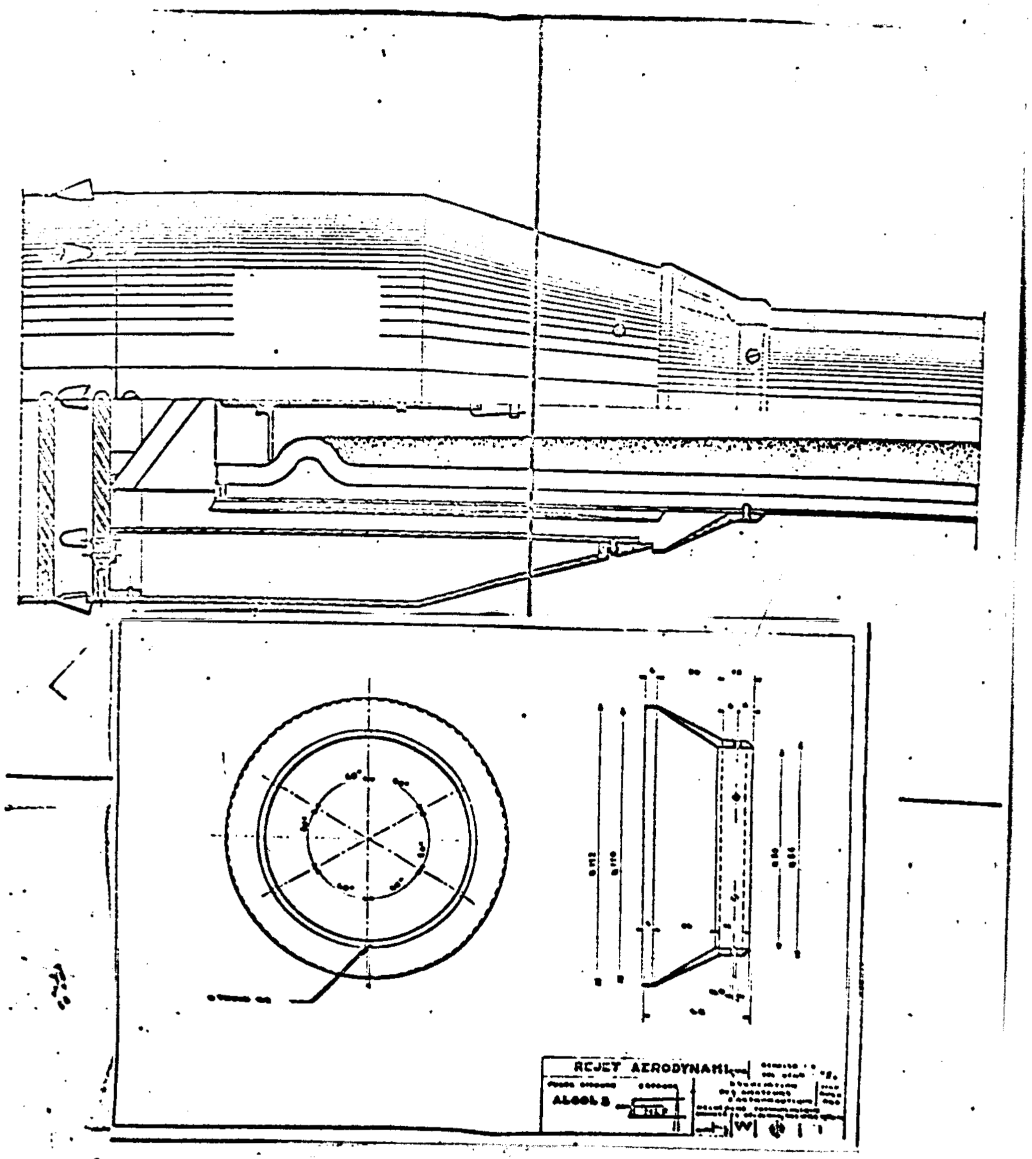


Figure 7. 2-stage rocket, detail of aerodynamical capsule

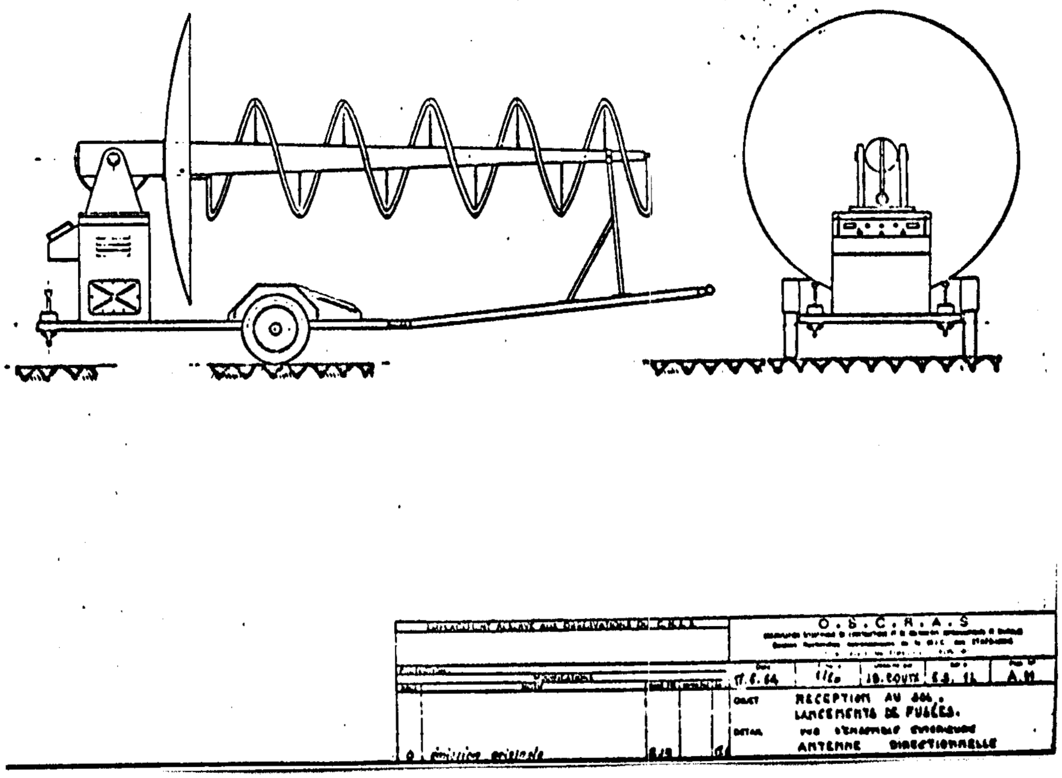


Figure 8. Rocket tracking directional antenna

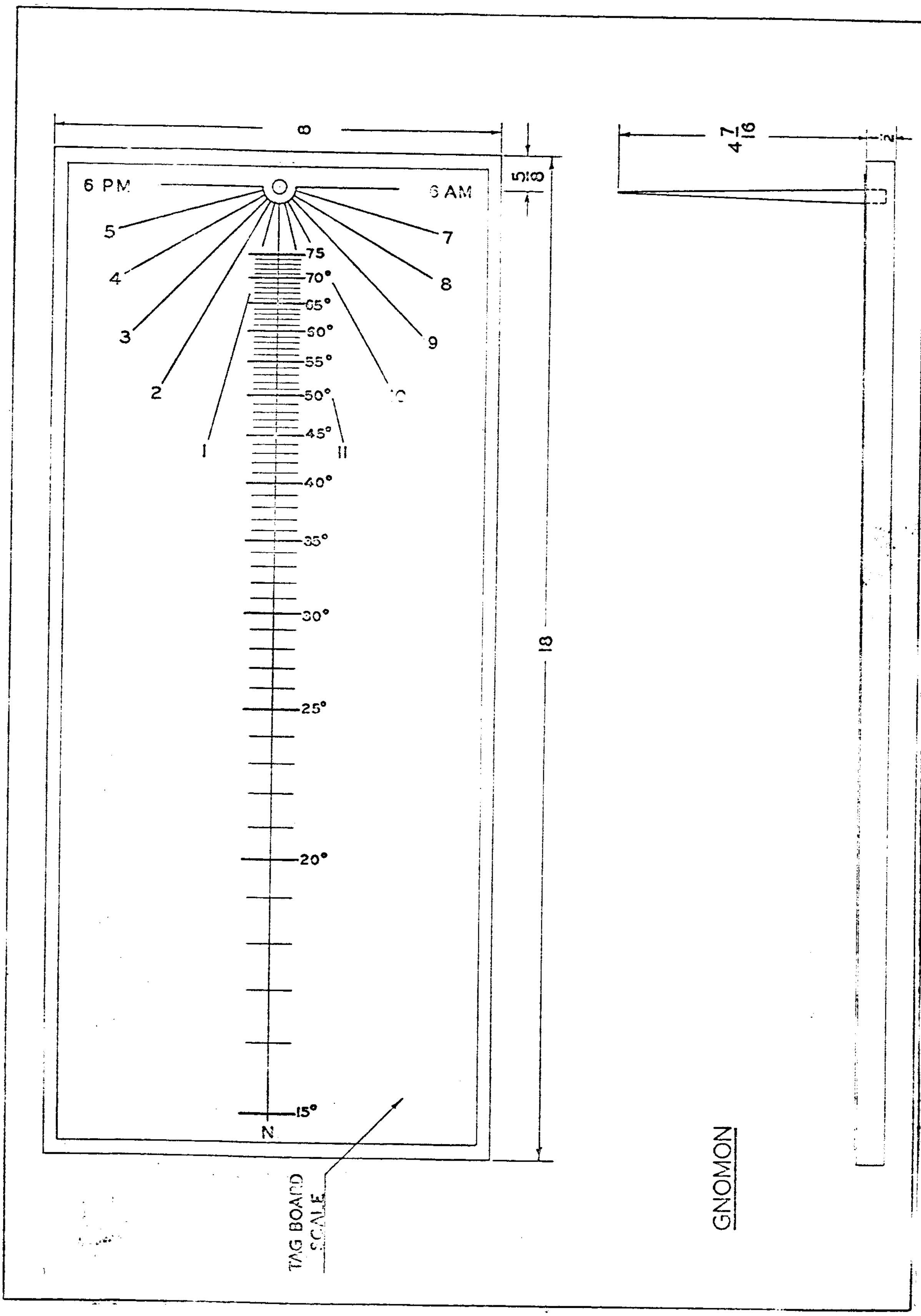

8
5/8
6 PM
6 AM
5
4
3
2
1
7
8
9
10
11
75
70°
65°
60°
55°
50°
45°
40°
35°
30°
25°
20°
15°
N
18
TAG BOARD SCALE
4 7/16
1/2
GNOMON

Figure 9

Appendix I

CIRCULAR OF AUGUST 7, 1962, No. 490, from the MINISTRY OF THE INTERIOR

Office of the Director General of the Sûreté Nationale,

Direction of Rules and Regulations,

Subdirection of Interior Rules and Regulations,

Office of the General Police

The Minister of the Interior

to

The Police Prefect and

The Prefects (Metropolitan Area)

Subject: Experimental Rockets

In cooperation with the Ministry of the Armed Forces, I have studied for several months the problems posed by the construction and the launching of experimental rockets by young people.

From all the information gathered, it appears that these activities are extremely dangerous, especially because of the handling of propellant mixtures without desirable safety precautions.

Under these conditions and in accordance with the Minister of the Armed Forces, I have decided to prohibit any initiative in this field without official control.

By this act of prohibition I do not want to discourage the effort of the young people in question, but to insure their protection as well as that of the population in general.

It will, therefore, be necessary from now on that young people who desire to build or launch experimental rockets first make official contact with the National Center of Space Studies, 129 rue de l'Université, Paris 7e (Tel.: INV. 49-39, ext. 444), which is authorized to direct such projects of young people, to provide them with all useful recommendations and, if necessary, to help them with preparations for their tests.

I leave up to you the ways of giving this circular all the publicity you may judge desirable, so that the construction and launching of experimental rockets by young people will take place, from now on, under conditions satisfactory to public safety.

For the Minister of the Interior
and by delegation,
The Director General of the
Sûreté Nationale,
Jacques Aubert.

Appendix II

Characteristics of the Engine Stage ATEF-74 [1]

given by CNES to the group of young people who propose a program of interesting scientific and technical experiments.

Body

made of a duraluminum tube

interior diameter:	150 mm
exterior diameter:	160 mm
length:	380 mm

Nozzles

made of soft iron with graphite neck

half angle of the top of the converging tube:		45°
half angle of the top of the diverging tube:		10°
neck cross section:	approximately	450 mm^2

Overall length of the body-nozzle combination: 530 mm

Fins

screwed to this engine is a 160 mm diameter tube on which are soldered, in cross configuration, fins of isosceles trapezoid form:

---

[1] For safety reasons the engine is delivered to the launching field. The coupling piece is delivered to the clubs during establishment of the program because it is needed for assembly of the rocket body.

overall span: 510 (160 + 2 x 175)

base side: 250 mm

outer side: 100 mm

Overall length of combined engine and fins: 696 mm (without coupling piece)

The total weight of the combined engine and fins (without coupling piece and without fuel) is of the order of 12.5 kg

Propellant Charge

consists of a 300 mm ling block of plastolite with a center hole having the form of a ten-sided star:

plastolite weight: 6.3 kg

inhibitor weight: 0.7 kg

Powder characteristics and engine performance

specific impulse: approximately 180 sec on ground under 4 MPa

combustion time: 4.65 ± 0.10 s

interior pressure of the chamber: approximately 4 MPa

thrust on ground: approximately 2,500 N.

This trust remains approximately constant during the whole period of combustion.